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Genetic Variability and Character Association Studies on Yield and Yield Attributing Traits in Maize (*Zea mays* L.) Inbreds

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Abstract:
A study was conducted to determine the magnitude and extent of genetic variability and trait interdependency among yield and its related characters using ninety-eight maize inbreds and four checks at department of Genetics and Plant Breeding, U.A.S. Dharawad, Karnataka, India, during Summer 2015. A good crop has been raised and evaluated by following RBD with two replications. Observations on fifteen yield related characters have been recorded and mean of each trait was subjected to analysis using WINDOSTAT v 8.0 software. ANOVA results revealed the existence of statistically significant difference among the inbreds considered for study. Trait means showed a wide range of variation and phenotypic variability was higher than genotypic variability, showing influence of environment on the yield related parameters. The high values of GCV and PCV for anthesis to silking interval (37.34; 48.40), grain yield per plant (39.10; 41.38) and fodder yield per plant (28.51; 31.31) suggested the possibility of improvement through direct selection for these traits. Another genetic parameter such as, high heritability coupled with high genetic advance over percent mean was observed for, anthesis to silking interval (59.50%; 59.33), cob weight (75.1; 60.64), kernels per row (22.84; 22.80) and grain yield per plant (41.38; 76.10) hence, selection for these traits can be practiced to improve yield and its associated traits. A significant and positive association with grain yield has been shown by, cob weight (0.89), cob length (0.52), kernel rows per cob (0.47) and shelling percentage (0.40), suggesting direct selection therefore, can be followed to improve economic yield. However, path coefficient analysis revealed that, cob weight (0.97), shelling percentage (0.30), days to 50 per cent silking, number of kernels per row, fodder yield and harvest index have highest direct effect on grain yield. The above study assured the occurrence wide genetic variability and determined the most important traits need to be considered for the improvement of grain yield.

Keywords: *Correlation, heritability, path coefficient, maize, variability, yield*

1. Introduction

Maize (*Zea mays* L.), is a multipurpose crop, used as food, feed, fodder and industrial raw material for the preparation of corn starch, corn oil, dextrose, corn syrup, corn flacks, gluten, grain cakes, alcohol, acetone etc. It has high productive potential among the cereals. Demand from industries, markets and domestic requirements can be met by increased production per unit area. Grain yield is a complex character and its expression depends upon the interaction of different yield parameters. The existence of genetic variability is essential to practice selection for yield and related traits and its effective when there is genetic variability among the inbreds selected. Direct selection for yield per se may not be the most efficient, but indirect selection for other yield related characters, with high heritability estimates will be more effective. Similarly, information on the correlation and path coefficients between grain yield with its parameters is prerequisite for improving grain yield through direct and indirect selections respectively.

Genetic variability for agronomic characters is a key component of breeding programme for improving the breeding material (Ahmad et al 2011). Characters with high heritability can easily be fixed with simple selection resulting in quick progress. Genetic advance shows the degree of gain obtained in a character under a particular selection pressure. High genetic advance coupled with high heritability estimates offers the most suitable condition for selection. Therefore, a good knowledge of these genetic parameters and their relative proportion existing in different yield contributing characters is a pre-requisite for effective crop improvement. Correlation studies explain and measures the true associations between yield and other related traits. It does not indicate the cause and effect relationship and consequently, a breeder may not be able to know which of the independent characters has the most direct effect on grain yield. Path coefficient analysis permits the separation of correlation coefficient into direct and indirect effects. Determining the yield components which have direct association and influence on yield and genetic variability among lines serves prime requirement of crop improvement activities. In this regard, maize inbreds developed at department of genetics and plant breeding, UAS Dharwad, were considered to determine various genetic parameters and nature of interrelationships among different traits in maize affecting grain yield and identify better inbred lines for improvement of grain yield via hybridization approaches.

2. Materials and Methods

The present experiment was conducted at Department of Genetics and Plant Breeding, College of Agriculture Dharwada, during *Summer* 2015. Study material consisted of ninety-eight maize inbred lines and four checks. Randomized Block Design with two replications was followed to evaluate for yield and its related traits. Recommended package of practices were followed to raise good crop. Observations were recorded on fifteen yield and yield related parameters like, Days Fifty per cent Taseling (DFT), Days to Fifty per cent Silking (DFS), Anthesis to silking interval (ASI), Plant Height (PHT), Cob height (CHT), Cob weight (CWT), Cob length (CLN), Cob Girth (CGR), Kernals Rows Per Cob (KRPC), Kernals Per Row (KPR), Test Weight (TW), Shelling Percentage (SP), Grain Yield per Plant (GYP), Fodder Yield per Plant (FYP) and Harvest Index (HI). Vernier caliper, electronic balance and measuring scale were used to estimate CGR, CWT and PHT respectively. Observations on five randomly selected plants from each line were collected and mean values were considered for genetic and association analysis using WINDOSTAT v8.0software. Genetic variability parameters such as, mean, range, Genotypic Variances (GV) and Phenotypic Variances (PV), Genotypic Coefficient of Variances (GCV), Phenotypic Coefficient of Variances (PCV), heritability in broad since (h^2) and genetic advance over percent mean (GAM) were calculated for all the respective character. Correlations between yield related traits and with yield were estimated. Path coefficients among yield and yield related parameters were also calculated using same software and drawn the following results.

3. Results and Discussion

Variability plays an important role in crop breeding, magnitude of variability present in crop species is the basis of selection. Analyses of variance (Table 1) showed that mean sum of squares due to genotypes were significant statistically, for all the characters studied. This indicated the presence of substantial genetic variability among the genotypes. Similar results were reported by (Sharma & Saikia 2000) for different maize characters like, plant height, ear height and grain yield per plant.

Wide range of genotypic and phenotypic variability was observed for Plant height (330.35; 826.90), cob height (138.36; 306.80), cob weight (1305.19; 1738.95) and grain yield per plant (948.44; 1062.52). Moderate estimates of genotypic and phenotypic variability were recorded for shelling percentage (78.95) and fodder yield per plant (85.34) respectively. Whereas, low genetic and phenotypic variability observed for days to fifty percent taseling, days fifty percent silking, anthesis to silking interval, cob girth and kernal rows per cob. This indicates presence of sufficient inherent genetic variability over which selection can be more effective. Similar findings in maize were also reported by Mahto et al (2002) for plant, grain yield per plant and ear height. Ratheret al (2003) observed high genetic variability in maize for yield per plant and ear height

The estimates of genotypic coefficient of variation (GCV) reflect the total amount of genotypic variability which is transmitted from parents to the progeny as reflected by heritability. In the present investigation the PCV was estimated to be high compared to GCV for all the traits considered. Phenotypic and genotypic coefficient of variability was high for anthesis to silking interval (48.40; 37.34), grain yield per plant (41.38; 39.10), fodder yield per plant (28.51; 31.31) and harvest index (48.38; 43.81). Medium PCV and GCV was observed for plant height (16.47; 10.41), cob length (18.36; 12.43) and shelling percentage (16.91; 11.96). Abiramiet al (2005) reported high PCV and GCV values for grain yield per plant and ear height in maize. Whereas, Moderate PCV values of ear girth, ear length, 100 grain weight and number of grain rows per cob were reported by Singh et al (2006).

Heritability estimates were found to be high, for all the traits such as, days to fifty per cent taselling (72.40%), cob length (45.80%) and cob girth (43.80%), indicating these character were least influenced by environmental effects. Since Heritability alone can't determine genetic improvement due to selection of individual genotypes, knowledge about genetic advance coupled with heritability is most useful. Expected genetic advance as per cent of mean indicates the mode of gene action in the expression of a trait, which helps in choosing an appropriate breeding method. In the present study high heritability coupled with genetic advance as percent mean was observed for anthesis to silking interval (59.50%; 59.33), cob height (45.30%; 23.84), cob weight (75.10%; 60.64) kernals per row (48.50%; 22.80), grain yield per plant (89.30%; 76.10), fodder yield per plant (82.90%; 53.49) and harvest index (82.00%; 81.71). Similar findings were reported by Satyanarayana et el (2003) for plant height, grain yield per plant in maize. Above results shows high expression of additive and dominant gene effects, where careful selection may lead towards improvement for these traits. Hence, provides better opportunities for selecting plant material for these traits in maize.

Source of variance	df	DFT	DFS	ASI	PHT	CHT	CWT	CLN	CGR
Replication	1	2.37	12.75	4.12	31.41	267.72	160.33	9.34	0.38
Treatment	101	14.14**	17.89**	4.69**	1157.24**	445.65**	3044.14**	10.17**	0.34*
Error	101	2.26	2.25	1.19	496.55	167.94	433.75	3.78	0.13
SEM		1.06	1.05	0.77	15.68	9.12	14.65	1.37	0.26
CV		2.25	2.13	30.80	12.76	18.91	19.59	13.52	9.72
CD		2.98	2.97	2.16	44.20	25.70	41.31	3.86	0.73
Source of variance	**df**	**KRPC**	**KPR**	**TW**	**SP**	**GYPP**	**FYP**	**HI**	
Replication	1	0.97	120.67	100.24	4.85	0.12	125.96	1.25	
Treatment	101	4.69**	40.42**	31.16**	236.81**	2010.96**	156.11**	3.53**	
Error	101	2.14	14.03	20.39	78.91	114.08	14.57	0.35	
SEM		1.03	2.63	3.18	6.25	7.51	2.69	0.42	
CV		10.90	16.40	19.22	11.95	3.56	12.93	20.54	
CD		2.90	7.43	8.95	17.62	21.18	7.57	1.74	

Table 1: Analysis of variance for yield and its component traits in maize inbreds at full grain maturity stage

Where,
** - Significant at both 0.01% and 0.05 % LOS; *- Significant at 0.01 % LOS
DFT- Days to fifty percent flowering; DFS-Days to fifty percent silking; ASI-anthesis to silking interval; PHT- Plant height (cm); CHT- Cob height (cm); CWT- Cob weight (g); CLN- Cob length (cm); CGR- Cob girth (cm^2); NKPC- Number of kernel rows per cob; NKPR- Number of kernels per row; TW-Test weight (g); SP-Shelling percentage (%); GYPP- Grain yield per plant (g); FYP-Fodder yield per plant (g); HI-Harvest index;

Trait	Mean	Range	GV	PV	GCV	PCV	h^2 (%)	GAM
DFT	66.77	60.00-74.00	5.94	8.20	3.635	4.29	72.40	6.39
DFS	70.31	62.00-78.00	7.82	10.07	3.98	4.51	77.70	6.40
ASI	03.54	01.00-9.00	1.75	2.94	37.34	48.40	59.50	59.33
PHT	174.62	118.0-256.0	30.35	826. 90	10.41	16.47	40.00	13.55
CHT	68.50	35.00-124.0	138.86	306.80	17.20	25.57	45.30	23.84
CWT	106.32	24.00-228.0	1305.19	1738.95	33.98	39.22	75.10	60.64
CLN	14.38	06.28-21.05	3.196	6.97	12.43	18.36	45.80	17.33
CGR	03.78	02.42-4.98	0.10	0.23	8.52	12.93	43.80	11.57
KRPC	13.42	09.2-21.80	1.275	3.41	8.41	13.77	37.30	10.59
KPR	22.84	08.80-38.40	13.19	27.23	15.90	22.84	48.50	22.80
TW	23.50	10.00-40.00	5.39	25.78	9.88	21.61	20.90	9.30
SP	74.32	30.59-97.30	78.95	157.85	11.96	16.91	50.00	17.42
GYPP	78.76	17.50-185.00	948.44	1062.52	39.10	41.38	89.30	76.10
FYP	29.50	10.00-58.00	70.77	85.34	28.51	31.31	82.90	53.49
HI	02.88	0.66-7.80	1.59	1.94	43.81	48.38	82.00	81.71

Table 2: Genetic variability parameters for yield related traits in maize inbreds at full grain maturity stage

Estimation of Correlation coefficients between yield and its related components helps the maize breeder to find out the nature and magnitude of the association between the traits which are mostly used to attain better yield (Wannows et al 2010). Association studies (Table 3) revealed the significant and positive correlation coefficients between grain yield with plant height (0.53), cob height (0.55), cob weight (0.89), cob length (0.52), cob girth (0.56), kernal rows per cob (0.47), kernals per row (0.63), test weight (0.40), shelling percentage (0.38) and fodder yield per plant (0.21). This could help the breeder to enhance high grain yield through selection for these traits. These findings are on par with Kashiani et al 2010. Grain yield was significantly and negatively correlated with days to 50 per cent tasseling (-0.41), silking (-0.53) and anthesis to silking interval (-0.29) indicating a reduction in days taken to tasseling and silking could increase the grain yield. Similar findings have also been reported by [Umakanth et al 2000; Appunu et al 2006]. Plant and ear height; cob length and diameter, kernals per row and test weight had strong and significant association with each other and grain yield, which are similar with findings of Shakoor et al 2007. These results indicate, taller plants with higher ear height in addition with more kernals per row, cob length and diameter contribute enhanced grain yield of maize. Therefore, selection on the basis of higher values of these traits would be helpful in yield improvement.
The analysis of path coefficient (Table 4) has been made to identify the important yield attributes by partitioning the correlation coefficient in to direct and indirect effects. High positive direct effect on grain yield was exhibited by cob weight (0.97) and shelling percentage (0.310) and moderate and positive direct effect by days to fifty per cent silking (0.10), fodder yield per plant (0.02), harvest index (0.02) and kernel per row (0.01), plant height (0.86), cob height (0.88), cob length (0.77), cob girth (0.80), kernel rows per cob (0.72) and test weight (0.74) exhibited highest indirect effects on yield via other yield related traits considered. Similar results were reported earlier by Bello et al 2010. Based on these results it can be suggested that, traits such as cob weight, shelling percentage can be used as selection criteria for grain yield improvement. The residual effects permit precise explanation about the pattern of interaction of other possible components of yield. The genotypic residual effects recorded 0.1178 it indicates the characters used in our experiment explain above 98.61 per cent of variations which may be contributed to higher yields in maize. Above results assures the existence of inherent genetic variability among the inbred lines considered for the study and significant association of yield attributing traits with grain yield. It infers the suitability of these inbreds as breeding material for improvement and development of high yielding Single cross hybrids or composites or varieties in maize.

	DFT	DFS	ASI	PHT	CHT	CWT	CLN	CGR	KRPC	KPR	TW	SP	FYP	HI	GYPP
DFT	1	0.84**	-0.11	-0.37**	-0.39**	-0.47**	-0.29**	-0.38**	-0.29**	-0.36**	-0.20	0.04	-0.07	-0.29**	-0.41**
DFS		1	0.44**	-0.39**	-0.38**	-0.51**	-0.31**	-0.49**	-0.39**	-0.42**	-0.28**	-0.15	-0.10	-0.35**	-0.53**
ASI			1	-0.10	-0.05	-0.15	-0.09	-0.27	-0.23	-0.17	-0.17	-0.35**	-0.07	-0.16	-0.29**
PHT				1	0.88**	0.55**	0.47**	0.49**	0.34**	0.52**	0.40**	0.01	0.16	0.33**	0.53**
CHT					1	0.58**	0.50**	0.50**	0.39**	0.56**	0.37**	-0.001	0.17	0.33**	0.55**
CWT						1	0.58**	0.60**	0.46**	0.64**	0.44**	-0.05	0.18	0.63**	0.89**
CLN							1	0.40**	0.40**	0.74**	0.37**	-0.02	0.06	0.38**	0.52**
CGR								1	0.65**	0.51**	0.47**	0.01	0.11	0.37**	0.56**
KRPC									1	0.50**	0.18	0.12	0.09	0.31**	0.47**
KPR										1	0.37**	0.12	0.12	0.43**	0.63**
TW											1	0.03	0.12	0.29**	0.40**
SP												1	0.04	0.27**	0.38**
FYP													1	0.69**	0.21
HI														1	-0.48**
GYPP															1

Table 3: Phenotypic correlation coefficients among yield and yield attributing parameters in maize inbreds at full grain maturity stage

Traits	DFT	DFS	ASI	PHT	CHT	CWT	CLN	CGR	KRPC	KPR	TW	SP	FYP	HI
DFT	**-0.07**	-0.06	-0.01	0.03	0.03	0.04	0.03	0.04	0.03	0.03	0.01	0.01	0.01	0.02
DFS	0.09	**0.10**	0.05	-0.05	-0.04	-0.06	-0.04	-0.07	-0.06	-0.06	-0.04	-0.04	-0.01	-0.04
ASI	-0.01	-0.03	**-0.07**	0.01	0.003	0.01	0.01	0.03	0.03	0.02	0.02	0.04	0.01	0.01
PHT	0.01	0.01	0.01	**-0.03**	-0.02	-0.02	-0.02	-0.02	-0.01	-0.02	-0.01	-0.01	-0.01	-0.01
CHT	0.01	0.01	0.01	0.86	**-0.03**	-0.02	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01	-0.01	-0.01
CWT	-0.56	-0.57	-0.18	-0.03	0.88	**0.97**	0.77	0.80	0.72	0.86	0.74	0.26	0.26	0.62
CLN	0.02	0.02	0.01	-0.02	-0.03	-0.03	**-0.04**	-0.03	-0.02	-0.04	-0.03	-0.01	-0.01	-0.02
CGR	0.02	0.02	0.01	-0.02	-0.02	-0.02	-0.02	**-0.03**	-0.02	-0.02	0.02	-0.01	-0.01	-0.01
KRPC	0.01	0.02	0.01	-0.01	-0.02	-0.02	-0.02	-0.02	**-0.03**	-0.02	-0.01	-0.01	-0.01	-0.01
KPR	-0.01	-0.01	-0.01	0.01	0.01	0.01	0.01	0.01	0.01	**0.01**	0.01	0.01	0.01	0.01
TW	0.01	0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	**-0.01**	-0.01	0.01	-0.01
SP	-0.02	-0.12	-0.21	0.06	0.05	0.08	0.10	0.10	0.08	0.11	0.08	**0.30**	0.02	0.14
FYP	-0.01	-0.01	-0.01	0.01	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.01	**0.02**	-0.01
HI	-0.01	-0.01	-0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-0.01	**0.02**

Table 4: Direct (diagonal) and indirect (off diagonal) effects of yield associated characters on yield in maize inbreds at full grain maturity stage, R square = 0.9861, Residual effect = 0.117

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